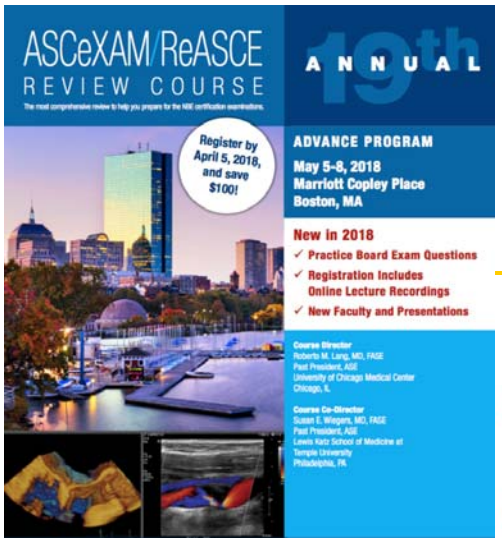


Guidelines for Chamber Quantification?

Roberto M Lang, MD

THE UNIVERSITY OF CHICAGO
CARDIAC IMAGING CENTER

@RobertoMLang

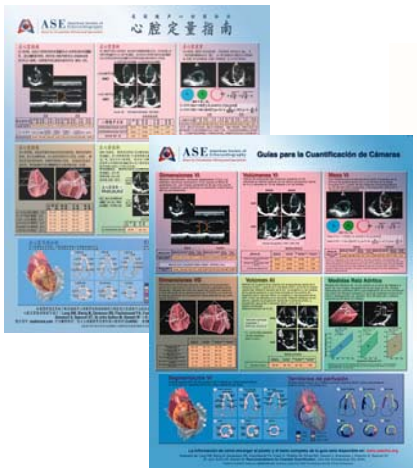
ASE American Society of Echocardiography
Heart & Circulation Ultrasound Specialists

Recommendations for Chamber Quantification: A Report from the American Society of Echocardiography's Guidelines and Standards Committee and the Chamber Quantification Writing Group, Developed in Conjunction with the European Association of Echocardiography, a Branch of the European Society of Cardiology

Members of the Chamber Quantification Writing Group are: Roberto M. Lang, MD, FASE, Michelle Bierig, MPH, RDCS, FASE, Richard B. Devereux, MD, Frank A. Flachskampf, MD, Elyse Foster, MD, Patricia A. Pellikka, MD, Michael H. Picard, MD, Mary J. Roman, MD, James Seward, MD, Jack S. Shanewise, MD, FASE, Scott D. Solomon, MD, Kirk T. Spencer, MD, FASE, Martin St John Sutton, MD, FASE, and William J. Stewart, MD

J AM Soc Echocardiogr 2005; 18:1440-1463

- Approximately 10,000 citations



iASE in iTUNE

美国超声心动图学会（ASE）委员会建议

美国超声心动图学会指南与标准委员会
和心腔定量分析起草小组
联合欧洲心脏病学会所属超声心动图学会
共同起草的报告：

关于心腔定量分析的建议

ASE COMMITTEE RECOMMENDATIONS

Recommendations pour la Quantification des Cavités Cardiaques: Le Rapport de La Société Américaine d'Échocardiographie, La comité de Direction des Standards et le bureau de rédaction sur La quantification des Cavités Cardiaques, développé avec l'association Européenne d'Échocardiographie, une branche de La société Européenne de Cardiologie

Roberto M. Lang, MD, FASE, Michelle Bierig, MPH, RDCS, FASE, Richard B. Devereux, MD, Frank A. Flachskampf, MD, Elyse Foster, MD, Patricia A. Pellikka, MD, Michael H. Picard, MD, Mary J. Roman, MD, James Seward, MD, Jack S. Shanewise, MD, FASE, Scott D. Solomon, MD, Kirk T. Spencer, MD, FASE, Martin St John Sutton, MD, FASE, and William J. Stewart, MD

Translators : Maéva Clerte, MD, Maryse Palardy, MD, Luc Anh Duy Pham, MD, et Anahita Dabo-Trubelja, MD, avec le soutien de Lawrence Rudski, MD, FASE
Supervisé par Marielle Scherrer-Crosbie, MD, PhD, FASE

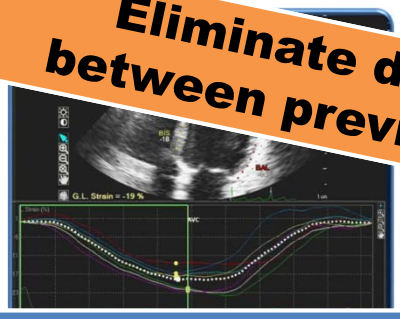
RECOMENDACIONES DEL COMITÉ DE LA ASE

Recomendaciones para la Cuantificación de las Cavidades: Informe del Comité de Guías y Estándares de la Sociedad Americana de Ecocardiografía y del Grupo Redactor de la Cuantificación de las Cavidades, desarrollado conjuntamente con la Asociación Europea de Ecocardiografía, rama de la Sociedad Europea de Cardiología

Cardiac Chamber Quantification: What is New?

Database

Eliminate discrepancies between previous guidelines



Deformation Imaging

RT3DE

EACVI
EUROPEAN ASSOCIATION OF CARDIOVASCULAR IMAGING
A Registered Branch of the ESC

ASE American Society of Echocardiography
Heart & Circulation Ultrasound Specialists

Recommendations for Cardiac Chamber Quantification by Echocardiography in Adults: An Update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging

Roberto M. Lang, MD, FASE, FESC, Luigi P. Badano, MD, PhD, FESC, Victor Mor-Avi, PhD, FASE, Jonathan Afilalo, MD, MSc, Anderson Armstrong, MD, MSc, Laura Ernande, MD, PhD, Frank A. Flachskampf, MD, FESC, Elyse Foster, MD, FASE, Steven A. Goldstein, MD, Tatiana Kuznetsova, MD, PhD, Patrizio Lancellotti, MD, PhD, FESC, Denisa Muraru, MD, PhD, Michael H. Picard, MD, FASE, Ernst R. Rietzschel, MD, PhD, Lawrence Rudski, MD, FASE, Kirk T. Spencer, MD, FASE, Wendy Tsang, MD, and Jens-Uwe Voigt, MD, PhD, FESC, *Chicago, Illinois; Padua, Italy; Montreal, Quebec and Toronto, Ontario, Canada; Baltimore, Maryland; Créteil, France; Uppsala, Sweden; San Francisco, California; Washington, District of Columbia; Leuven, Liège, and Ghent, Belgium; Boston, Massachusetts*

Eur Heart J Cardiovasc Imaging. 2015 Mar;16(3):233-71. J Am Soc Echocardiogr 2015;28:1-39

In Chinese …….

新版关于成人超声心动图心腔定量方法的建议

写作小组成员： Roberto M. Lang, MD, FASE, FESC, Luigi P. Badano, MD, PhD, FESC, Victor Mor-Avi, PhD, FASE, Jonathan Afilalo, MD, MSc, Anderson Armstrong, MD, MSc, Laura Ernande, MD, PhD, Frank A. Flachskampf, MD, FESC, Elyse Foster, MD, FASE, Steven A. Goldstein, MD, Tatiana Kuznetsova, MD, PhD, Patrizio Lancellotti, MD, PhD, EFSC,vDenisa Muraru, MD, PhD, Michael H. Picard, MD, FASE, Ernst R. Rietzschel, MD, PhD, Lawrence Rudski, MD, FASE, Kirk T. Spencer, MD, FASE, Wendy Tsang, MD, and Jens-Uwe Voigt, MD, PhD, FESC, *Chicago, Illinois; Padua, Italy; Montreal, Quebec and Toronto, Ontario, Canada; Baltimore, Maryland; Creteil, France; Uppsala, Sweden; san Francisco, California; Washington, District of Columbia; Leuven, Liege, and Ghent, Belgium; Boston, Massachusetts.*

中文翻译：美国加尼福尼亚大学戴维斯分校医学中心 范大立
美国纽约艾伯特爱因斯坦医学院 叶清
中国上海交通大学附属仁济医院 沈学东
美国内布拉斯加大学医学中心 谢峰
中文校对：中国山东大学医学院齐鲁医院 张运
美国塔夫斯大学滨州医学中心

过去 10 年科技的快速发展，以及这些发展给超声心动图实践带来的变
进行全面更新，而这正是美国超声心动图学会和欧洲心血管影像协会

Partition Values for Severity of Abnormalities

- **Cutoffs based on SD**
  - **Data readily exist**
  - **Echo parameters are not normally distributed**
  - **Asymmetric distribution**
- **Cutoffs based on percentile values (95^{th})**
- **Cutoffs based on outcomes or prognosis**
- **Cutoffs based on consensus**
- **LV EF, LA, LA size and LV mass**

Normal Reference Values for 2DE

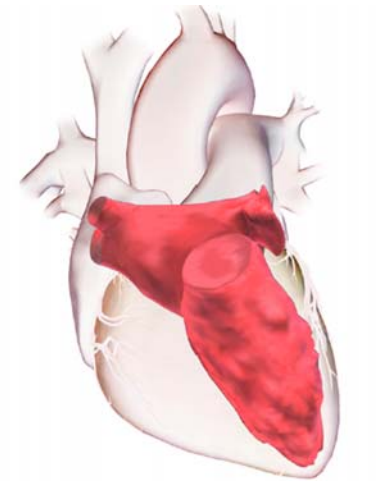
- **Seven data *bases (Asklepios, Flemengho, Cardia5, Cardia 25, Padua 3D Echo Normal, Norre Study)***
- **No contrast studies**
- **Age, gender, ethnicity, height and weight**
- **Nl BP, no diabetes, nl BMI, creatinine, glomerular filtration rate, cholesterol, LDL and triglicerides**

RV ASSESSMENT: 3D Echocardiography

WASE Normal Values Study

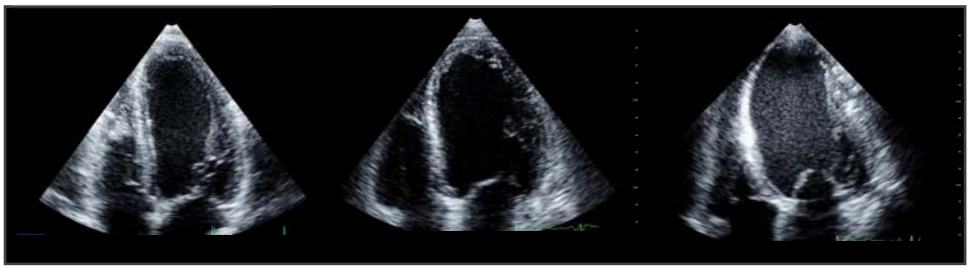
Normal values anticipated for all 2D and 3D echo parameters including strain

Left Ventricle and Left Atrium



Eye ball

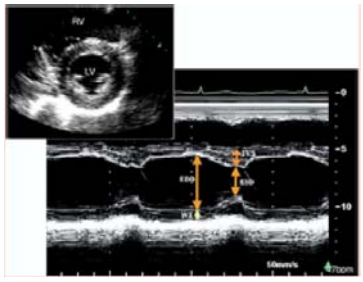
How do we Assess LV Function ?

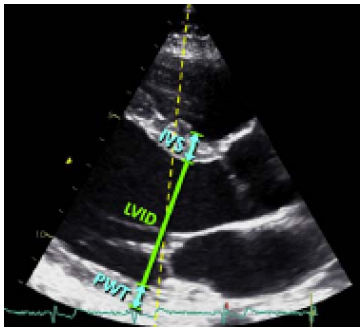


Qualitative Assessment

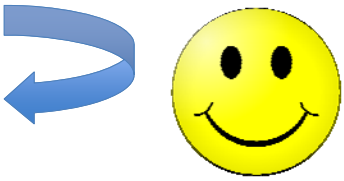
- **Subjective**
- **Experience dependent**
- **Lack of standardization**
- **Large inter- and intra-observer variability**

Left Ventricular Linear Measurement



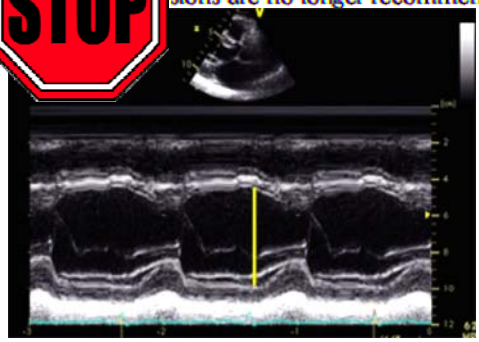


1.1. Linear Measurements. It is recommended that linear internal measurements of the left ventricle and its walls be performed in the parasternal long-axis view. Values should be carefully obtained perpendicular to the LV long axis and measured at or immediately below the level of the mitral valve leaflet tips. In this regard, the electronic calipers should be positioned on the interface between the myocardial wall and cavity and the interface between the wall and the pericardium. Internal dimensions can be obtained with a two-dimensional (2D) echocardiography (2DE)–guided M-mode approach, although linear measurements obtained from 2D echocardiographic images are preferred to avoid oblique sections of the ventricle (Table 1).



Left Ventricular Volumetric Measurement

1.2. Volumetric Measurements. LV volumes are measured using 2DE or 3DE. Volume calculations derived from linear measurements may be inaccurate, because they rely on the assumption of a fixed geometric LV shape such as a prolate ellipsoid, which does not apply in a variety of cardiac pathologies. Accordingly, the Teichholz and Quinones methods for calculating LV volumes from LV linear dimensions are no longer recommended for clinical use.

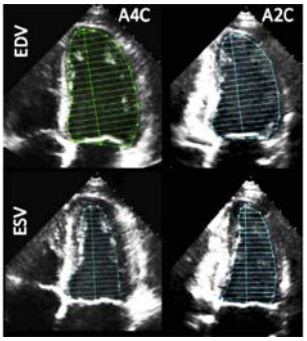


TEICHHOLZ Formula

$$V = \frac{7 \times D^3}{2.4 + D}$$

Am J Cardiol 1976;37:7–11

Left Ventricular Volumetric Measurement

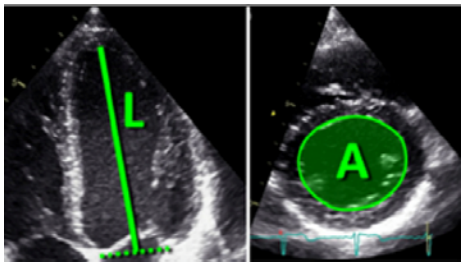


1

Biplane Disk Summation

- Corrects for shape distortions
- Less geometrical assumptions compared with linear dimensions

- Apex frequently foreshortened
- Endocardial dropout
- Blind to shape distortions not visualized in the apical two- and four-chamber planes



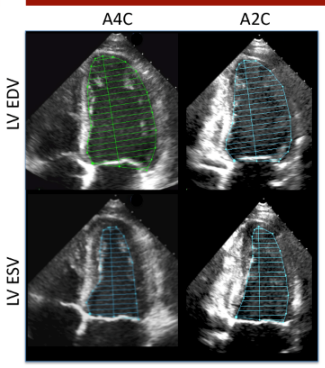
Area Length Method

- Partial correction for shape distortion

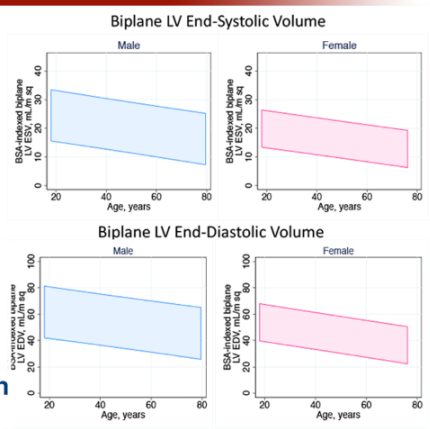
2

- Apex frequently foreshortened
- Heavily based on geometrical assumptions
- Limited published data on normal population

LV Volumes by 2D



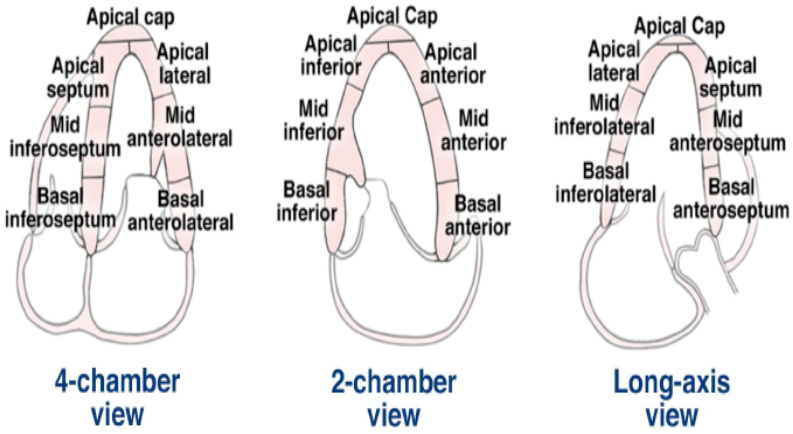
Biplane disc's summation



Parameters	Male		Female	
LV volumes normalized by BSA	Mean ± SD	2SD Range	Mean ± SD	2SD Range
LV end-diastolic volume, mL/m²	54 ± 10	34 - 74	45 ± 8	29 - 61
LV end-systolic volume, mL/m²	21 ± 5	11 - 31	16 ± 4	8 - 24

2-D measurements for LV volume calculations using the biplane method of discs, in the apical four-chamber (A4C) and apical two-chamber (A2C) views at end diastole (LV EDD) and at end-systole (LV ESD).

LV Segmentation



4-chamber view

2-chamber view

Long-axis view

Left Ventricular Ejection Fraction

	Normal	Mild	Moderate	Severe
2015	>52	51-41	40-30	<30
2005	>55	54-45	44-30	<30

LV Ejection Fraction

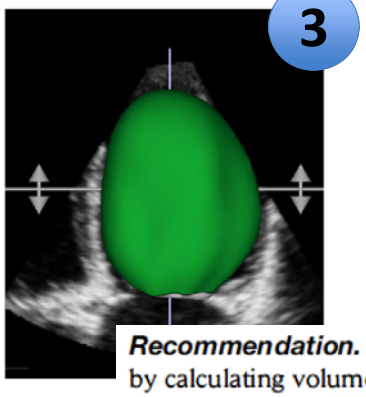
Male

	Normal	Mildly	Moderately	Severely
LVEF	52-72	41-51	30-40	<30

Female

	Normal	Mildly	Moderately	Severely
LVEF	54-74	41-53	30-40	<30

LV Volumes by 3D



3

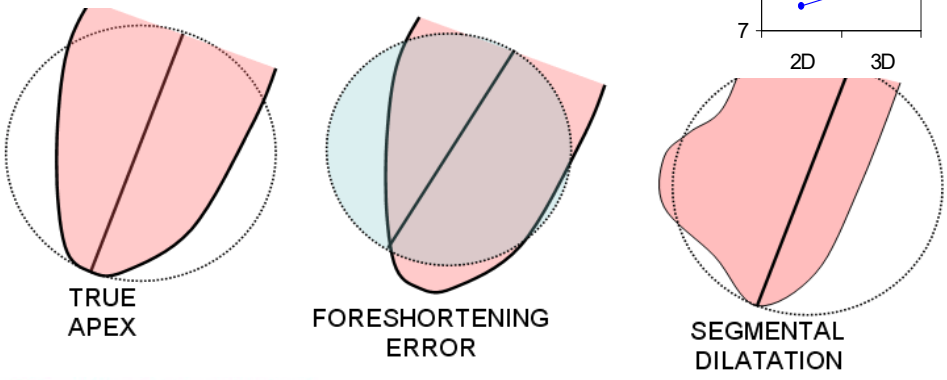
Upper limits of normal:

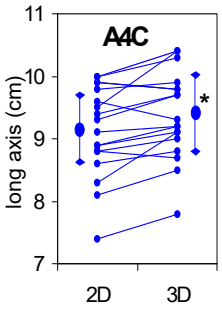
EDV:
79 ml/m² for men
71 ml/m² for women

ESV:
32 ml/m² for men
28 ml/m² for women

Recommendation. LV size should be routinely assessed on 2DE by calculating volumes using the biplane method of disks summation technique. In laboratories with experience in 3DE, 3D measurement and reporting of LV volumes is recommended when feasible depending on image quality. When reporting LV linear dimensions, the recommended method is 2D-guided measurements. LV size and volume measurements should be reported indexed to BSA. For general reference, 2D echocardio-

Why is 3D More Accurate?

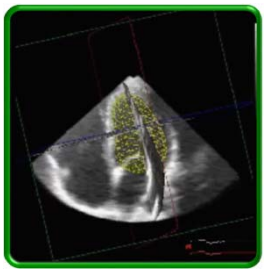




THE UNIVERSITY OF CHICAGO MEDICINE
Heart and Vascular Center

Mor-Avi V, Lang RM et al., *Circulation* 2004. 110: 1814-1818.

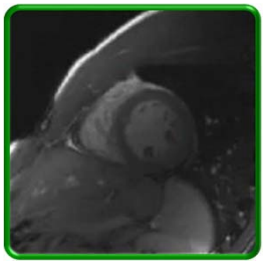
Validation by MRI



EDV, ESV

Excellent correlation
(r^2>0.85)

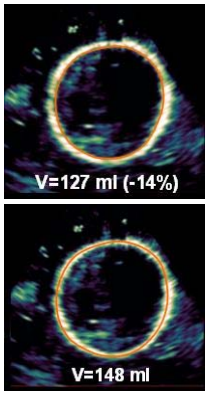
but RT3DE underestimates volumes



- **Jacobs LD, et al.** ***Eur Heart J 2005; 27:460-8***
- **Sugeng L, et al.** ***Circulation 2006; 114:654-61***
- **Jenkins C, et al.** ***J Am Soc Echocardiogr 2007; 20:962-8***
- **Soliman OI, et al.** ***Am Soc Echocardiogr 2007; 20:1042-9***

Sources of error

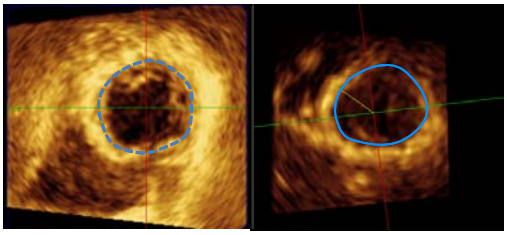
- **Latex balloon:**



True volume: **150 ml**

- **Human ventricles**:

Patient A Patient B



- Tracing error is the most important factor contributing to LV volume underestimation

- Mor-Avi V. et al, *JACC Cardiovasc Img 2008: 1: 413-423*

LV Volumes: 3DE

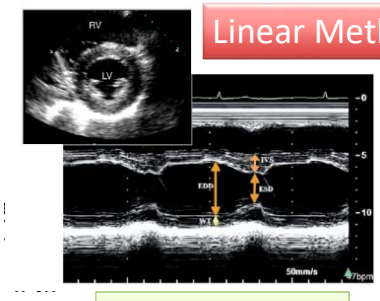
✓ Advantages

- Avoid image foreshortening
- No geometric assumptions
- More accurate and reproducible

✗ Disadvantages

- Low temporal resolution
- Less data on normals

LV Mass



Linear Method

Cubed Formula

2D Methods

Area Length

Truncated ellipsoid

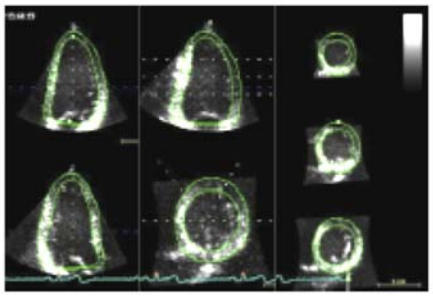
	Men	Women
LV Mass/BSA	49-115	43-95
RWT, cm	0.24-0.42	0.22-0.42
Septal WT, cm	0.6-1.0	0.6-0.9
PWT, cm	0.6-1.0	0.6-0.9

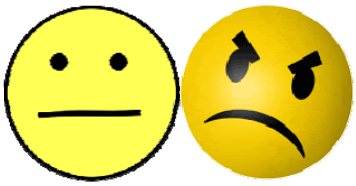
	Men	Women
LV mass/BSA, g/m^2	50-102	41-88

LV Mass

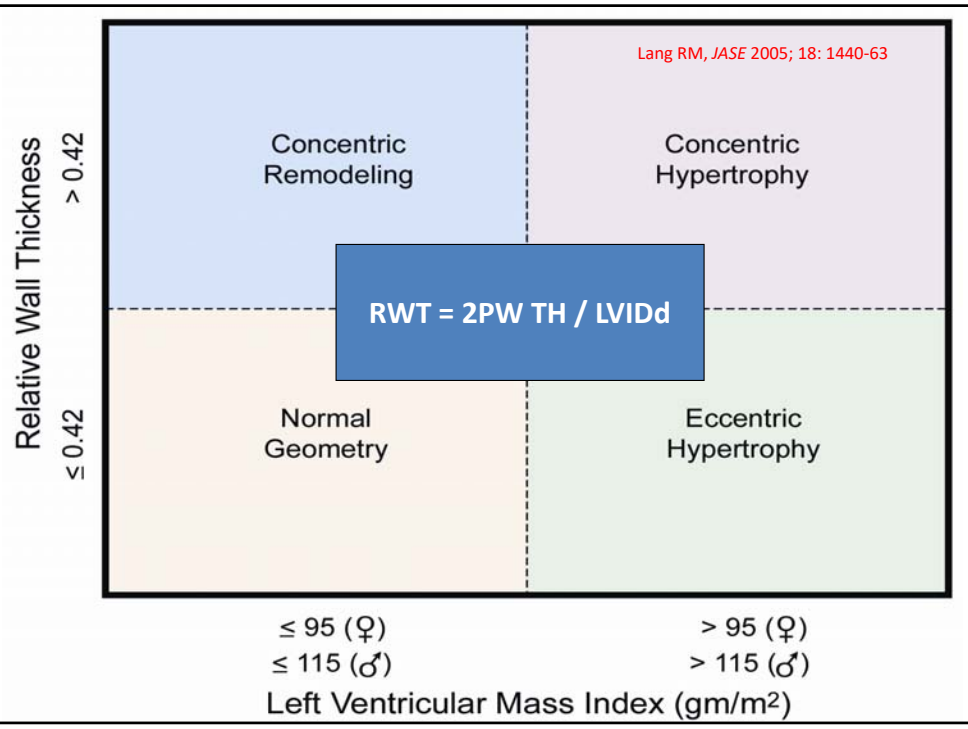
- Direct measurement without geometrical assumptions about cavity shape and hypertrophy distribution
- More accurate that the linear or the 2D measurements
- Higher inter-measurement and test/retest reproducibility
- Better discriminates small changes within a patient

3D Methods

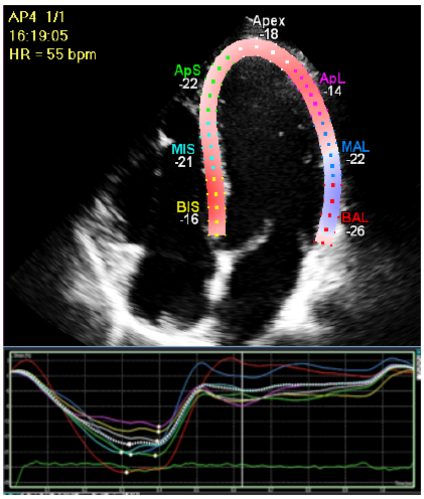




Normal values less well established
Dependent on image quality
Patients cooperation required



LV Global Longitudinal Strain



Peak GLS in the range of -20% can be expected in a healthy person

- **Low Flow AS**
- **Cardio-oncology**
- **Valvular Regurgitation**

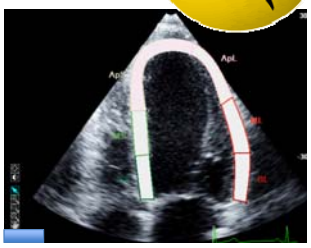
LV Global Longitudinal Strain

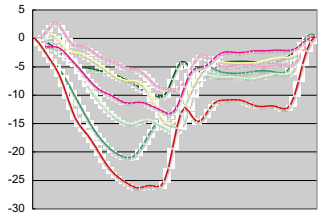
ultrasound imaging industry.[24,26] Because of intervendor and intersoftware variability and age and load dependency, serial assessment of GLS in individual patients should be performed using the same vendor's equipment and the same software.

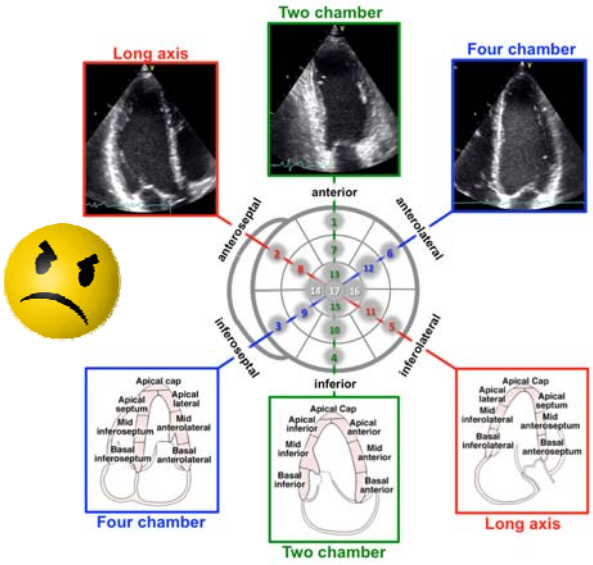
The preponderance of currently available data is for midwall GLS. There are concurrent definitions as a basis for GLS calculation using endocardial, midwall, or average deformation.[24] This committee refrains from recommendations in this regard and refers to the ongoing joint standardization initiative of the ASE, EACVI, and the ultrasound imaging industry.[24,26] Because of intervendor and

LV Segmentation: Regional Deformation

- Quantitative assessment of the magnitude of regional LV deformation is not recommended
  - lack of reference values
  - suboptimal reproducibility
  - considerable inter-vendor measurement variability

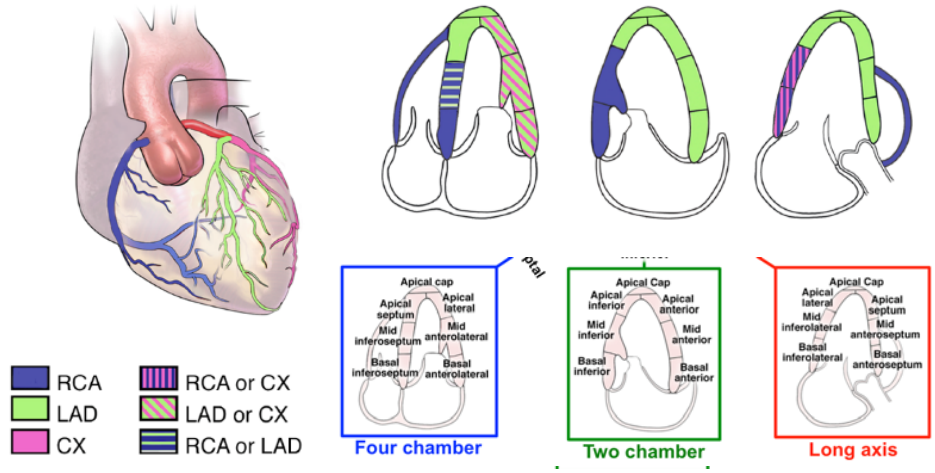




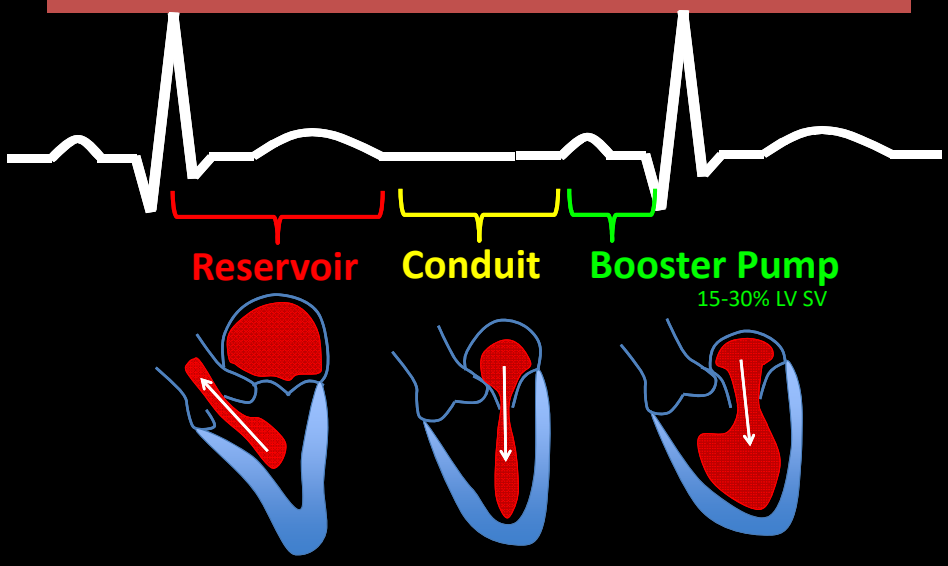


1. Normal or Hyperkinetic
2. Hypokinetic (reduced thickening)
3. Akinetic (absent or negligible thickening
4. Dyskinetic (systolic thinning or stretching)

Perfusion Territories

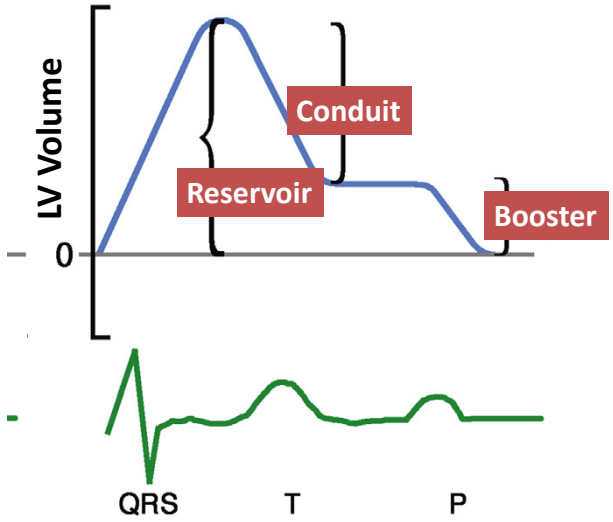


The Left Atrium



Mehrzad et al. Int. J. Mol. Sci. 2014, 15, 15146-15160

Left atrial function – 3DE



Left atrial function

Table 1 Volumetric Indexes of LA Function

LA Function	LA Volume Fraction	Calculation
Global function; reservoir	LA EF (or total EF)	$[(LA_{max} - LA_{min})/LA_{max}]$
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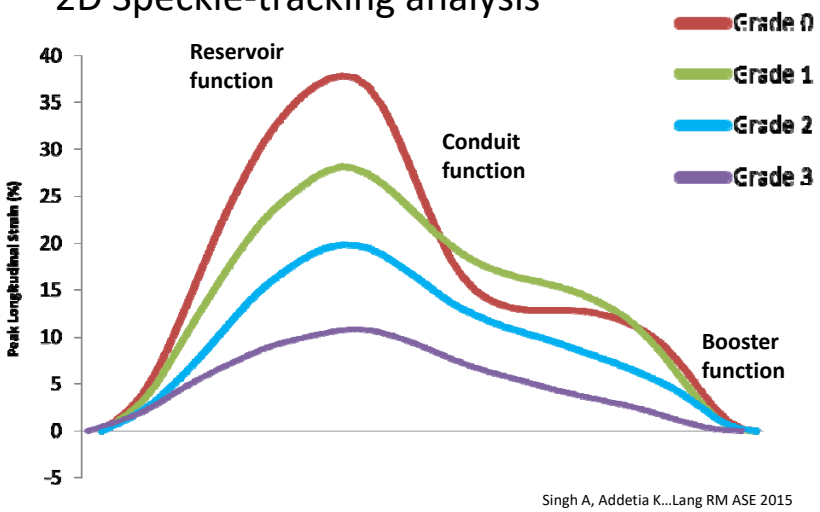
Hoit BD. J Am Coll Cardiol 2014;63:493–505

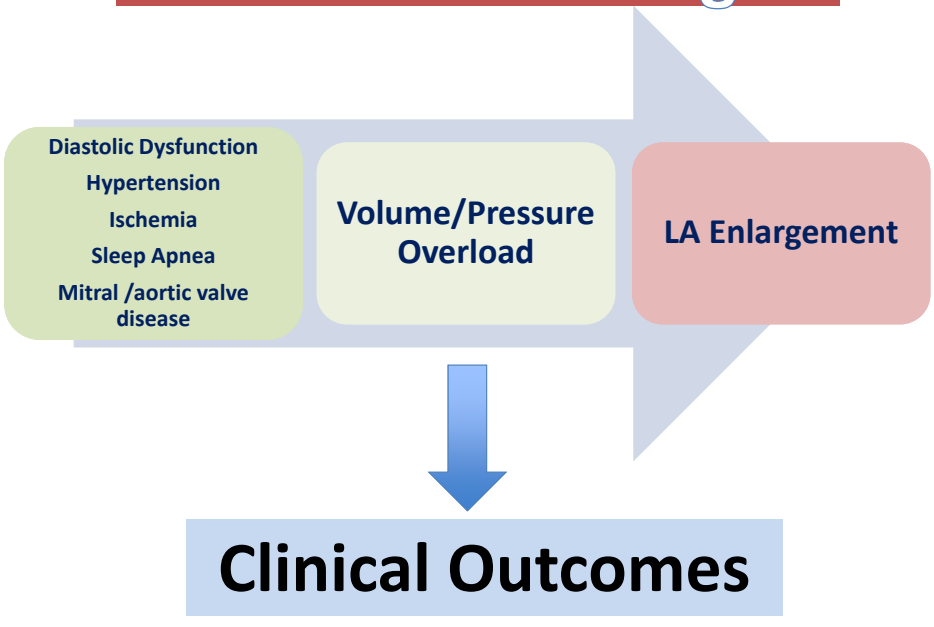
Left atrial function – 2DE

- 2D Speckle-tracking analysis



Singh A, Addetia K...Lang RM ASE 2015

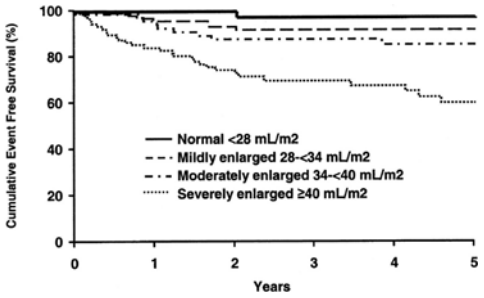
LA Remodeling



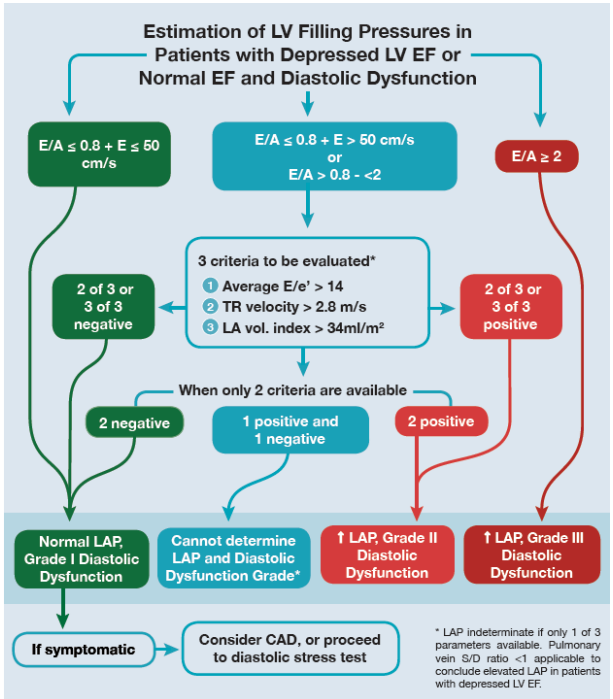
3D Echo for Assessing the Left Atrium

LA size has a powerful prognostic value in a variety of clinical conditions:

- atrial fibrillation
- systolic heart failure
- diastolic dysfunction
- chronic coronary artery disease
- myocardial infarction
- mitral regurgitation
- systemic hypertension
- stroke
- hypertrophic cardiomyopathy
- renal failure



Tsang, T.S.M. et al. J Am Coll Cardiol 2006



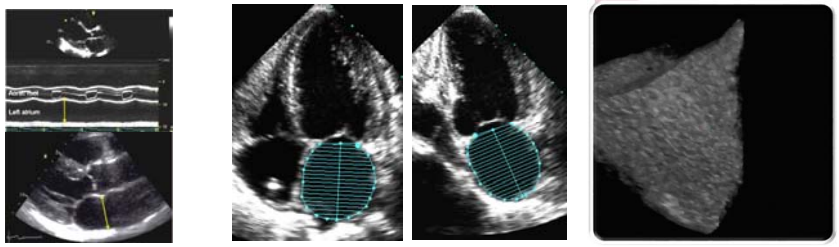
Assesment of Left Atrial Size/Volumes

Diameters
- M-mode
- 2D guided

Area
- 4Ch

Volume
- Calculated from 2D
- Measured by 3D

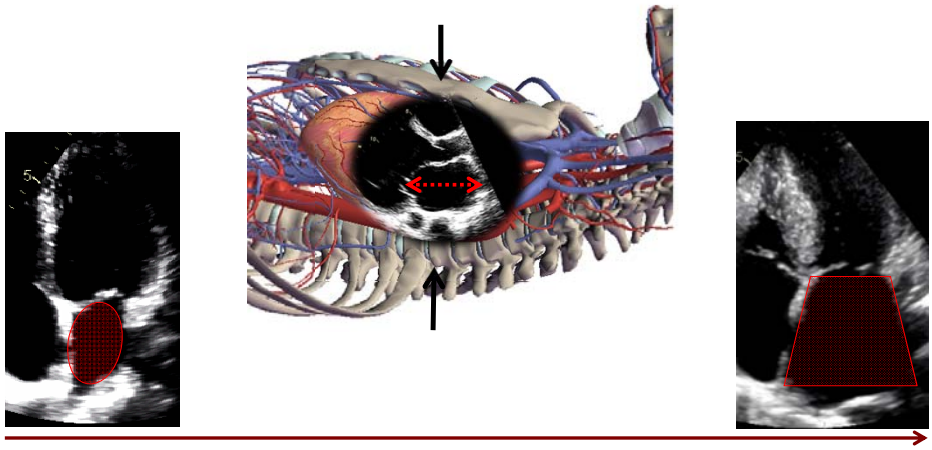
TIME EVOLUTION



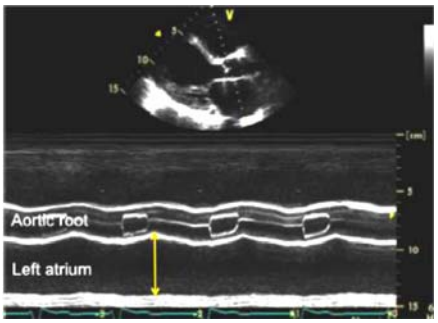
3D Echo for Assessing the Left Atrium

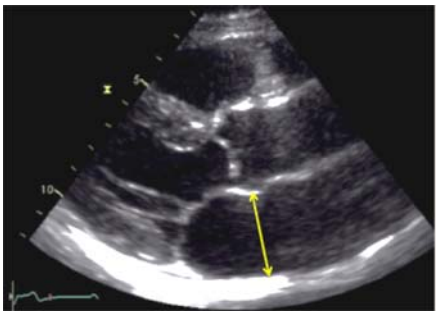
Assymmetrical LA Remodelling

- LA enlargement does not occur uniformly in all directions

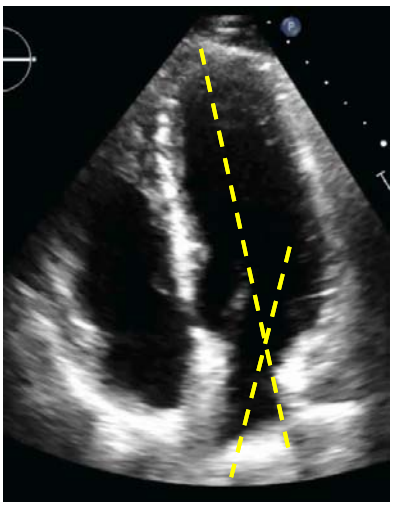


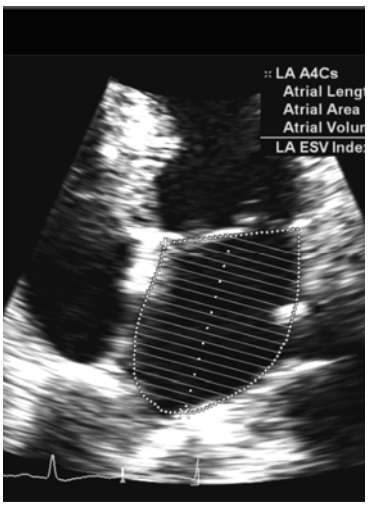
LA Linear Dimension



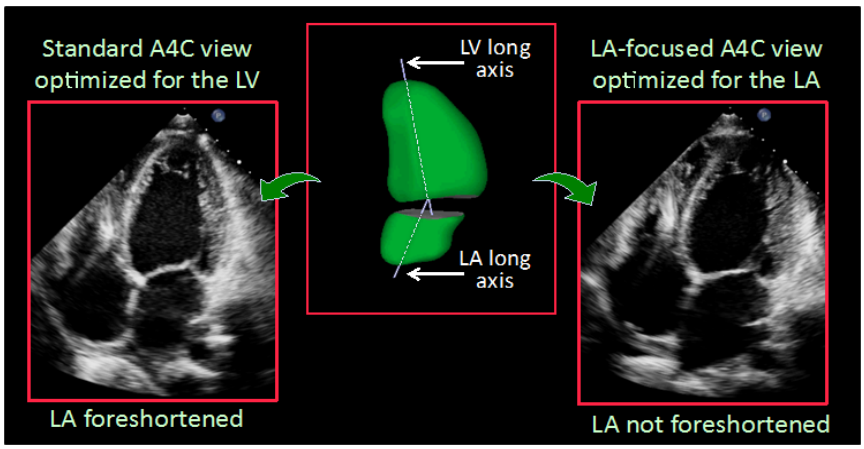


LA Volume





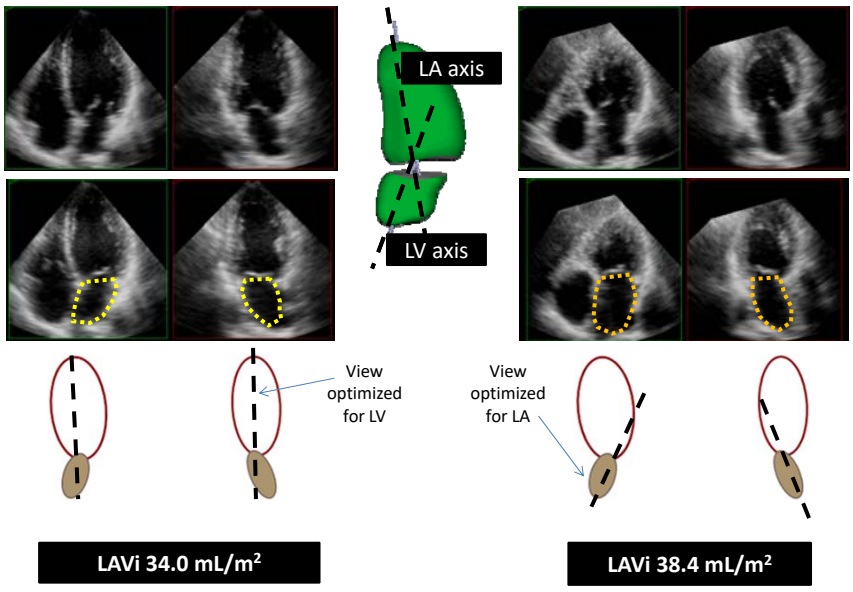
Left atrial volume on 2DE



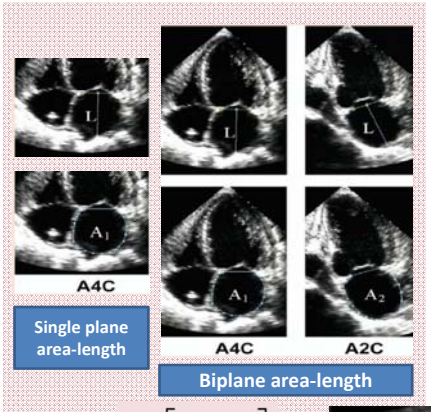
Accuracy of 2DE is limited:

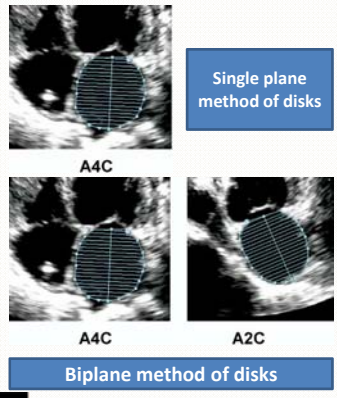
- View-dependent
- Geometrical assumptions
- Measured on apical views optimized for LV

Left atrial volume on 2DE



LA volume assessment on 2DE



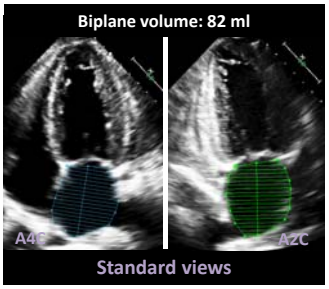


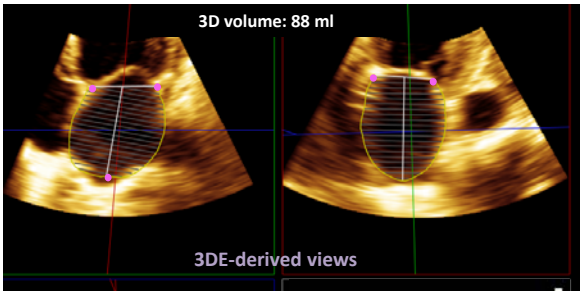
$$\frac{8}{3\pi}\left[\frac{(A_1 \cdot A_2)}{L}\right]$$

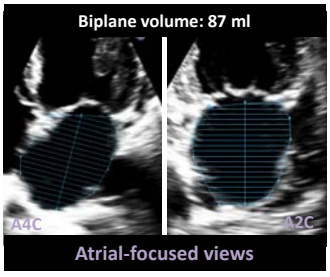
ASE/EACVI Chamber Quantification Guidelines 2015

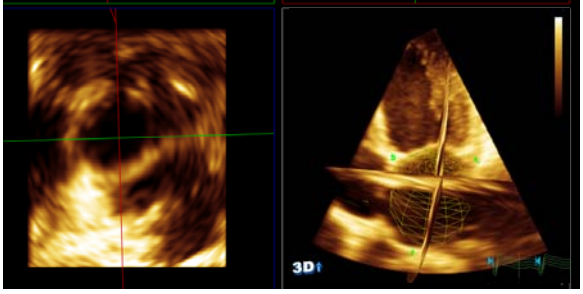
3D Echo

Left atrial volume on 2DE



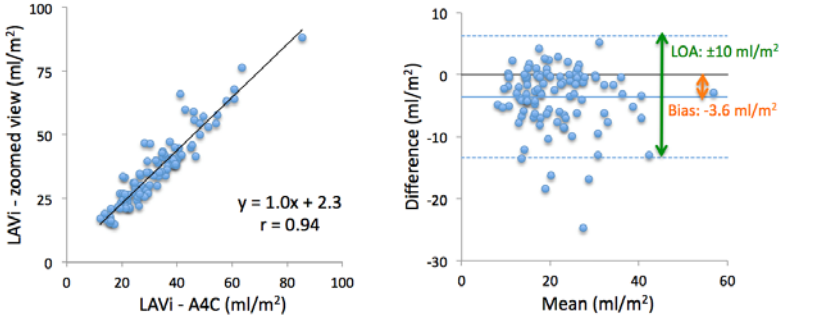






Left atrial volume on 2DE

- **LA volumes obtained from non-foreshortened LA-focused views correlated highly with those obtained from conventional A4C views (r=0.94), but were larger (Bland Altman bias 7 ml, limits of agreement ±19 ml).**



V. Mor-Avi, Addetia K and Lang RML work in progress

LA Volume

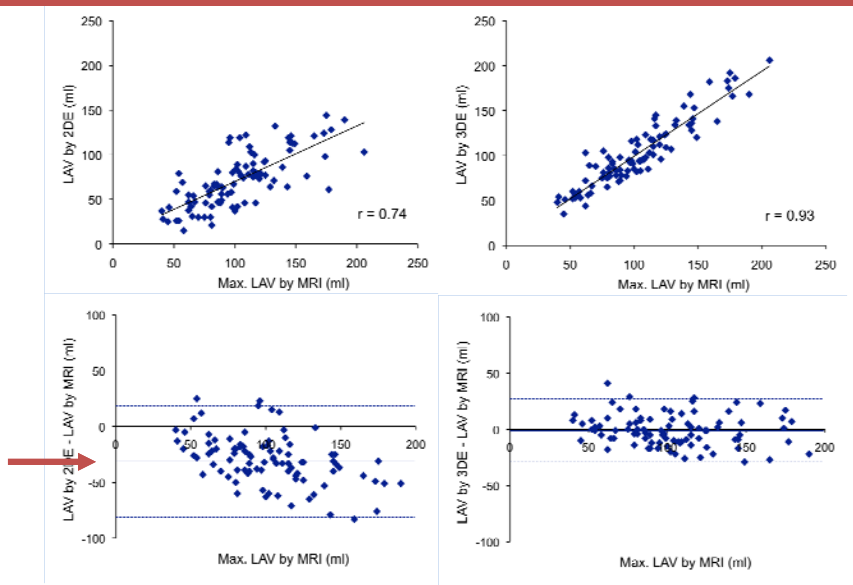
	Normal	Mildly	Moderately	Severely
LA Vol/BSA	16-28	29-33	34-39	>40

Lang RM et al; J Am Soc Echocardiogr 2005; 18:1440-1463

	Normal	Mildly	Moderately	Severely
LA Vol/BSA	16-34	35-41	42-48	>48

Lang RM et al; J Am Soc Echocardiogr 2015; 28:1-39

2DE vs. 3DE for LA Volume Quantification



Mor-Avi V ,Lang RM et al.: Real-time 3D echocardiographic quantification of left atrial volume: Multicenter study for validation with magnetic resonance imaging. JACC Imaging 2012.

Left atrial function

Table 1 Volumetric Indexes of LA Function

LA Function	LA Volume Fraction	Calculation
Global function; reservoir	LA EF (or total EF)	$[(LA_{max} - LA_{min})/LA_{max}]$
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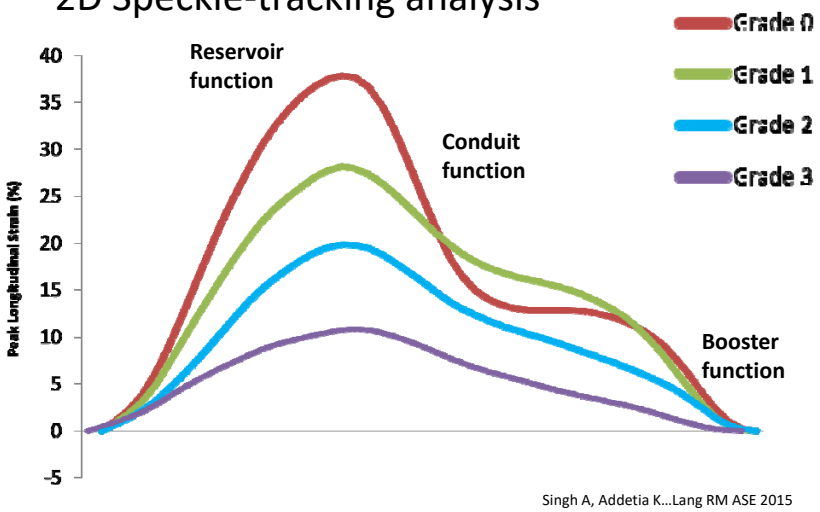
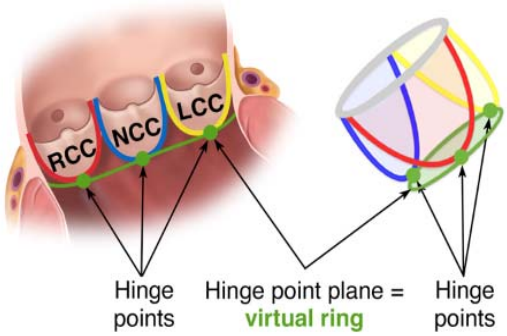
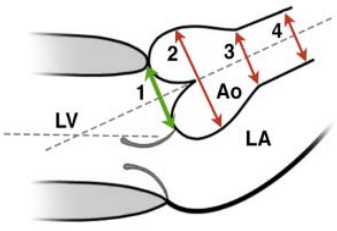


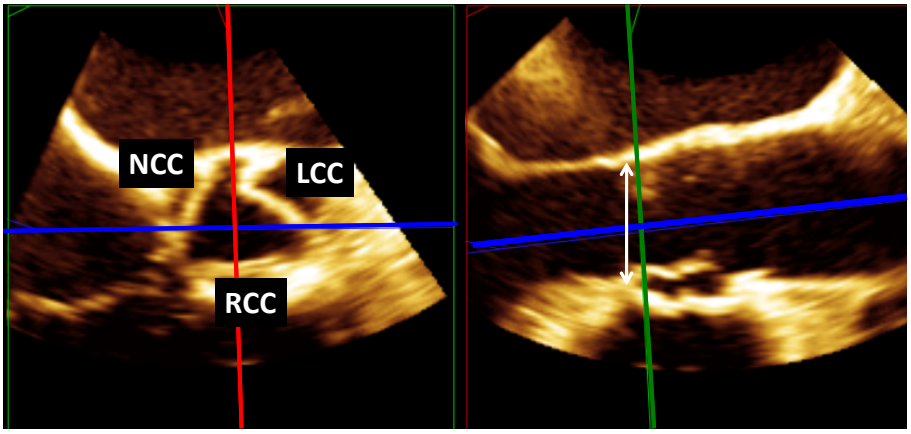
Singh A, Addetia K...Lang RM ASE 2015

Aorta





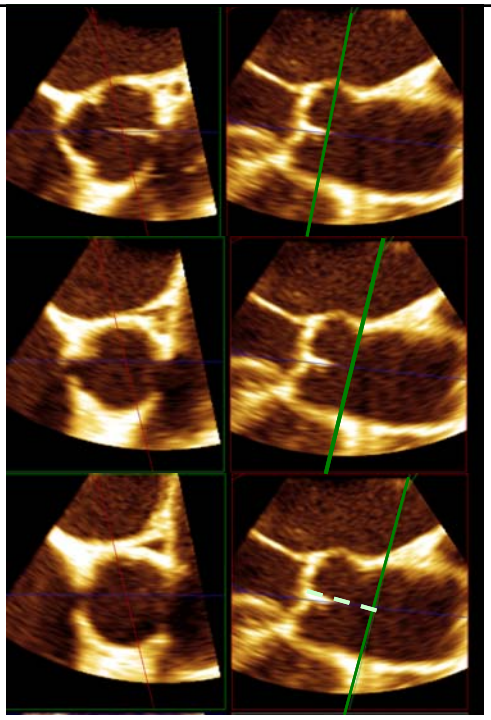
Aortic Annulus Measurements

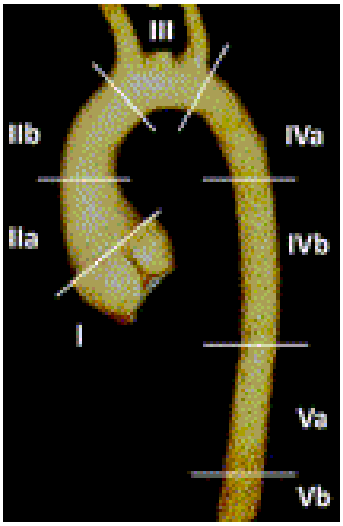


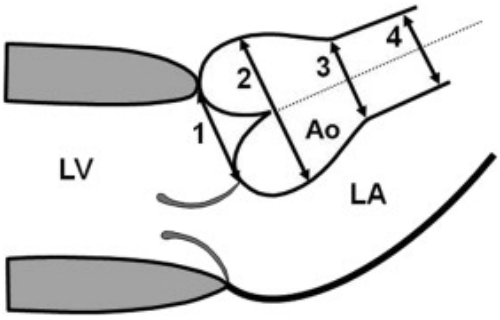
When: mid-systole: slightly larger and rounder
Where: mid right coronary cusp and the edge of the commissures between the LCC and NCC from inner edge to inner edge

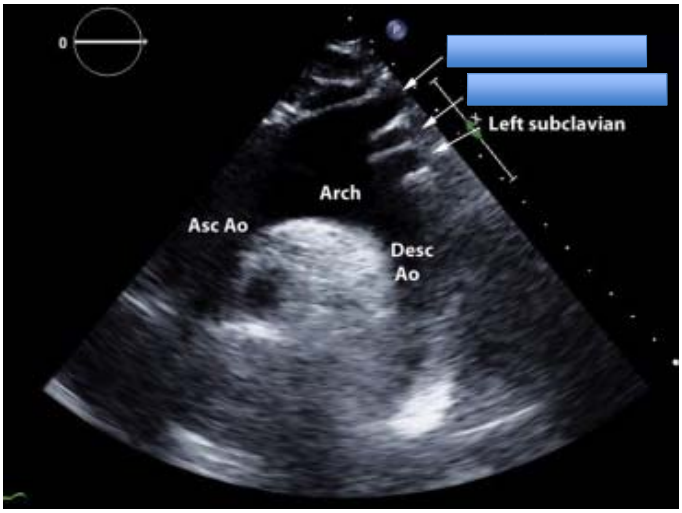
- Sinuses of Valsalva (End-diastole)
- Sino-tubular junction (End-diastole)
- Maximal diameter of the proximal Asc Ao (End-diastole)

Leading edge to leading edge

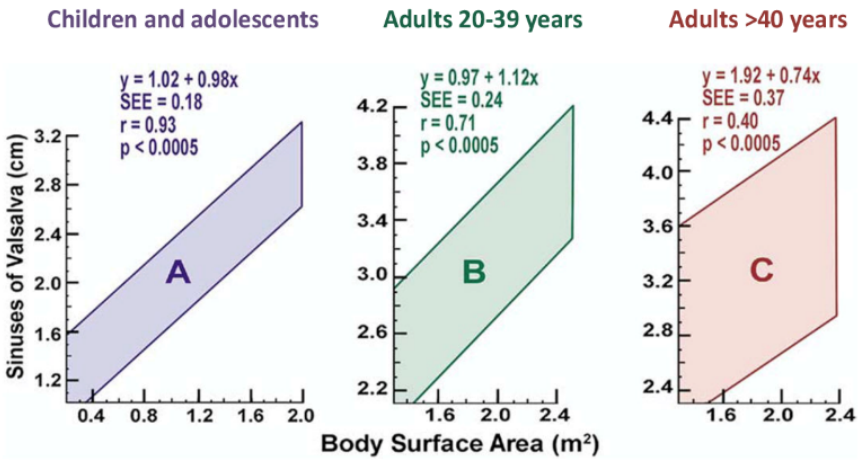



III
IIb
IIa
I
IVa
IVb
Va
Vb


1
2
3
4
Ao
LV
LA


Left subclavian
Arch
Asc Ao
Desc
Ao

Aortic Root Measurements (Sinus of Valsalva)



Summary

1. Reference ranges for left ventricular volumes and ejection fraction as well as LA volumes have changed in the recent guidelines due to the use of large echo databases.
2. Left ventricular wall motion scoring has changed to a 4-grade system.
3. Three-dimensional echocardiography is recommended for measurement of left and right ventricular volumes if possible.

Summary

4. If global longitudinal strain is being used to follow patients, it should be using the same vendors machine and analysis package.

Lang et al. Recommendations for Cardiac Chamber Quantification by Echocardiography in Adults: An Update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. J Am. Soc. Echocardiogr. 2015;28:1-39.

http://asecho.org/wordpress/wp-content/uploads/2015/01/ChamberQuantification2015.pdf

Thanks for your attention

@RobertoMLang